

A TEST OF THE CONDITION-BIAS HYPOTHESIS YIELDS DIFFERENT RESULTS FOR TWO SPECIES OF SPARROWHAWKS (*ACCIPITER*)

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ABSTRACT.—The determination of body condition of birds is important for many field studies. However, when using trapping methods based on food as a lure, the sample of trapped birds could be biased toward individuals in poor physical condition. We provide information on body mass, body condition, and sex and age ratio of Levant Sparrowhawks (*Accipiter brevipes*) and Eurasian Sparrowhawks (*Accipiter nisus*) caught in Elat, southern Israel, during spring migration. We compared physical condition of birds trapped in baited traps to physical condition of birds trapped in mist nets (no bait). The body mass and index of physical condition of migrating Levant Sparrowhawks trapped in baited traps was lower than birds trapped in mist nets. By comparison no differences were detected in body mass and condition index of migrating Eurasian Sparrowhawks caught by the different trapping methods. The differences found in condition of Levant Sparrowhawks trapped with and without food support the predictions of the condition-bias hypothesis; however, data from the Eurasian Sparrowhawk do not. The extent to which biases occur may be different even for closely related species. *Received 1 Oct. 1998, accepted 7 Jan. 1999.*

Using food to trap animals, especially predators, is probably the most widespread capture method used by biologists. The capture of birds of prey involves many methods, most of which use small birds and rodents as lures (Clark 1981, Bloom 1987). These trapping methods are vulnerable to sampling bias because hungry birds in poor condition are more likely to overcome their fear of entering traps compared to birds in good condition (Weatherhead and Greenwood 1981). Considerable support for this condition-bias hypothesis comes from studies of songbirds (Weatherhead and Greenwood 1981, Dufour and Weatherhead 1991) and ducks (Greenwood et al. 1986, Hepp et al. 1986, Reinecke and Shaiffer 1988, Conroy et al. 1989). We know of no such studies conducted on birds of prey.

Two species of sparrowhawks occur regularly during spring migration at Elat, Israel. The Levant Sparrowhawk (*Accipiter brevipes*) breeds in Russia, eastern Europe, and the Balkans. It migrates in large flocks to Africa in September, returning in May (Cramp and Simmons 1980). In autumn sparrowhawks pass over northern Israel between mid-September and the beginning of October; up to 41,700 birds were counted during one autumn (Leshem and Yom-Tov 1996). During spring they

return through southern Israel between 20 April and the beginning of May, with up to 49,800 birds counted during one season (Clark et al. 1986, Shirihi 1996). The Eurasian Sparrowhawk (*Accipiter nisus*) breeds across the Palearctic region (Newton 1986). In contrast to the Levant Sparrowhawk only a few hundred Eurasian Sparrowhawks pass through Israel during autumn (Dovrat 1986, Leshem and Yom-Tov 1996) and spring (Clark et al. 1986, Shirihi 1996).

Physical condition during spring migration is significant, not only for the successful completion of the migratory journey, but also for the timing of arrival at the breeding grounds and the condition of nutrient reserves required for successful breeding. The breeding success of birds in the temperate zone typically declines as the breeding season progresses. Body condition and amount of nutrient reserves have been shown to affect breeding success in a variety of species (Korschgen 1977, Moss and Watson 1984, Newton 1986). McLandress and Raveling (1981) demonstrated the importance of spring nutrient reserves for migration as well as for reproduction and their effect on clutch size in Canada Geese (*Branta canadensis*). Price and coworkers (1988) suggested that the ability to accumulate sufficient reserves required for breeding may prevent the evolution of progressively earlier breeding dates. Spring migrants arrive in Elat after crossing desert areas where feed-

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ing opportunities are probably limited. Thus, it is important to investigate the occurrence of condition biases which may go undetected and lead to misinterpretation of data collected from trapped birds (Weatherhead and Greenwood 1981, Gorney and Yom-Tov 1994).

In conjunction with a spring migration raptor banding project, we captured Eurasian and Levant sparrowhawks using a variety of trapping methods. Our objective was to test the condition-bias hypothesis in birds of prey and to compare the physical condition of spring migrants to condition of pre-breeding sparrowhawks.

METHODS

Migrating sparrowhawks were captured as part of a raptor banding project during five consecutive spring migration seasons between March and May in 1984–1988, in the agricultural areas just north of Elat (29° 33' N 34° 55' E), Israel (Clark et al. 1986). Birds were caught in mist nets, bal-chatri traps, and bow nets (Bloom 1987) commonly used by hawk researchers in North America and conforming to regulations applied there. Only bal-chatri and bow-nets were placed on the ground using food as a lure. Three-meter tall, 4 shelf mist nets were placed in palm groves along rows of trees used for roosting by sparrowhawks. The distance between the lured traps and mist nets was generally at least 500 m. Occasionally small birds were caught in mist nets and they may have lured some sparrowhawks into the nets. Such cases were excluded from the data analysis when detected.

All birds were measured, weighed to the nearest 1 g, and banded before release. Wing chord (straight line from wrist to wing tip, without stretching or flattening the wing) was measured with a ruler to the nearest 1 mm. Culmen length was measured to 0.1 mm using Manostat calipers. Age and sex were determined by plumage, eye color, and size (Cramp and Simmons 1980). Age was determined as either adult (two years old or more) or yearling (approximately one year old, i.e., birds in their second calendar year).

We compared the body mass and body condition index (body mass/wing chord \times culmen length) of Levant and Eurasian sparrowhawks that were caught in mist nets to those that were caught in baited traps (bal-chatri and bow-nets). Comparisons were conducted on four groups; adult and yearling females, and adult and yearling males. Sample sizes vary slightly because we lack measurements for several individuals. This particular physical condition index was used because of its high correlation with fat reserves in migrating Steppe Buzzards (*Buteo buteo vulpinus*; Gorney and Yom-Tov 1994). We found similar results however, using the more commonly employed index of body mass divided by wing length.

To test whether birds in poorer body condition are more likely to be attracted to baited traps than birds in

better condition, we compared for each age and sex category the body mass and condition index of birds trapped with baited traps and birds trapped in mist nets (no bait). We also compared the number of individuals from each age and sex class that were trapped in baited and non-baited traps.

We used Abstat and Minitab 6.1.1 programs for IBM compatible computer for statistical analysis. All variables were tested for normality. When assumptions were met we used separate SD *t*-tests. If normality assumptions were not met we used Mann-Whitney tests. All probabilities are two-tailed.

RESULTS

Levant Sparrowhawk.—Although Levant Sparrowhawks pass through Elat during three weeks, we captured 90% of all age and sex categories within a mean of 9.4 (yearling males) and 10.5 (adult females) days (means calculated for 5 years of the study). Although the passage for this species is concentrated and rapid, adults were trapped earlier than yearlings with median capture dates of 24 April for adult males, 25 April for adult females and 26 April for yearling males and females. We caught 425 Levant Sparrowhawks, 404 of which we sexed and aged. Slightly more yearlings were trapped (52%) than adults (48%) at Elat. Sex ratio deviated from the expected 1:1 ratio in favor of males in both adults (61.1% males, 38.9% females; $n = 193$; $\chi^2 = 9.58$, $P = 0.002$), and yearlings (56.9% males, 43.1% females; $n = 211$; $\chi^2 = 3.98$, $P = 0.046$).

Body masses of adult males and females were significantly larger than those of yearlings (Table 1). We found no significant differences between condition indices of adult and yearling birds (Table 1). Thus, much of the difference in mass appeared to be due to the smaller size of yearling birds (Table 1). We also found no significant associations within age and sex groups between date of migration and physical condition, nor did the physical condition of trapped birds vary with time of day.

Mean condition index of adult females was significantly higher than condition index of adult males (Mann-Whitney $U = 1862$, $P = 0.001$, two-tailed test). Similarly yearling females were in better condition than yearling males (Mann-Whitney $U = 1740$, $P = 0.001$, two-tailed test).

We found no significant differences be-

TABLE 1. Body mass (g), wing chord (mm), and condition index (body mass/wing chord × culmen length) of adult and yearling male and female Levant Sparrowhawks caught in Elat 1984–1988.

Group	Body mass (g)					Wing chord (mm)					Condition index				
	Mean	SD	n	t	P	Mean	SD	n	t	P	Mean	SD	n	t	P
Adult male	169	17	18			217	6	118			0.062	0.007	94		
Yearling male	159	16	120	4.4	<0.001	209	5	120	10.9	<0.001	0.061	0.006	83	1.1	<0.05
Adult female	215	25	69			234	5	70			0.065	0.007	58		
Yearling female	199	20	88	4.0	<0.001	224	5	90	10.4	<0.001	0.065	0.006	65	0.5	<0.05

tween males and females ($\chi^2 = 0.313$, $P > 0.05$, $df = 1$) nor between adults and yearlings ($\chi^2 = 0.024$, $P > 0.05$, $df = 1$) in proportion of birds trapped in baited and non-baited traps. The mean body mass and mean condition index of adult males and yearling females trapped in mist nets was higher than the mean body mass and condition index of birds trapped in baited traps ($P < 0.05$; Table 2). Adult females and yearling males demonstrated no difference in mean condition index between both kinds of traps (Table 2).

Eurasian Sparrowhawks.—Most Eurasian Sparrowhawks (90%) pass through Elat in five weeks. As with Levant Sparrowhawks, adults were trapped before yearlings. Median capture date was 14 April for adult males and females, 20 April for yearling females and 22 April for yearling males. We trapped 72 Eurasian Sparrowhawks, with slightly more yearlings (53%) than adults (47%). Sex ratio among adults ($n = 35$; 43% males, 75% females), did not deviate from the expected 1:1 ratio ($\chi^2 = 1.48$, $P > 0.05$), but did deviate among young birds in favor of females ($n = 37$; 27% males, 73% females; $\chi^2 = 7.81$, $P = 0.005$).

Mean body mass of adult females was significantly larger than that of yearling females ($P < 0.05$), and their wing chord was significantly longer ($P < 0.01$; Table 3). However, the large body mass of adult females was not due to size difference alone since their physical condition index was significantly higher than that of yearling females ($P < 0.05$; Table 3). We also found no significant difference in mean body mass or physical condition index between adult and yearling males (Table 3). However, the wing chord of adult males was significantly longer than that of yearling males ($P < 0.01$; Table 3). Females in both age groups had significantly higher condition indices than males (Mann-Whitney $U = 13$, $P < 0.001$; $U = 65$, $P = 0.04$, for adults and yearlings, respectively). No association was found between index of physical condition and between time of day and date of capture.

We found no significant differences in body mass and condition indices between Eurasian Sparrowhawks trapped in lured traps and in mist nets. Significantly more females (33 of 48) than males (6 of 18) were trapped in baited traps ($\chi^2 = 12.3$, $P < 0.001$, $df = 1$). A similar proportion of adults (16 of 35) and

TABLE 2. Comparison of body mass and condition index of Levant Sparrowhawks caught in mist nets (no lures) and in lured traps, Elat 1984–1988.

	Mistnets			Lured traps			Comparison	
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>t</i>	<i>P</i>
Body mass								
Adult females	19	213	27	39	219	23	0.74	>0.05
Adult males	35	175	18	61	167	17	2.06	0.043
Yearling females	22	208	16	49	197	21	2.42	0.019
Yearling males	29	162	19	55	157	14	1.14	<0.05
							Mann-Whitney	
							<i>W</i>	<i>P</i>
Condition index								
Adult females	19	0.065	0.007	39	0.065	0.007	1142	>0.05
Adult males	34	0.064	0.008	60	0.061	0.006	2568	0.027
Yearling females	21	0.068	0.005	44	0.063	0.006	1261	0.008
Yearling males	29	0.062	0.007	54	0.060	0.006	2124	>0.05

yearlings (23 of 37) were trapped in baited traps ($\chi^2 = 1.96$; $P > 0.05$, $df = 1$).

DISCUSSION

Physical condition of migrants trapped with food as a lure may be subject to biases (Weatherhead and Greenwood 1981). One of the prominent differences we found between the two *Accipiter* species is that the condition index of Levant Sparrowhawks captured with and without food as a lure supports the condition-bias hypothesis, but we found no evidence for a condition-bias for Eurasian Sparrowhawks. Thus, the occurrence and extent of a condition-bias may be different even for closely related species of approximately the same body size trapped during the same study using the same traps. Although few data are available to determine the cause of this difference, several aspects of their migration strategies may be pertinent. Physical condition of birds on the wintering grounds, and food availability could differ for the two species. In addition, they may differ in their tendencies to hunt during migration. Levant Sparrowhawks migrate mainly in large flocks whereas Eurasian Sparrowhawks migrate singly (Cramp and Simmons 1980, Shirihi 1996). Levant Sparrowhawks might not regularly hunt in areas like Elat where many birds would be unlikely to find food. Therefore only weak individuals would hunt and the species would demonstrate a condition-bias. On the other hand, all Eurasian Sparrowhawks may

hunt regularly as has been described from other migrating populations and species (Rudebeck 1950, Cochran 1972, Newton 1986) and thus show no evidence for a condition-bias.

When baited traps are used, age bias can occur with more younger birds trapped than older individuals (Nass 1964). Indeed, more yearling than adult Steppe Buzzards were trapped in Elat during the same years (Gorney and Yom-Tov 1994). However, we detected no age bias in the capturing of the two *Accipiter* species.

Migrating Eurasian Sparrowhawks do not appear to store extra fat for migration. Moritz and Vauk (1976) found that birds trapped during autumn and spring migration at Helgoland weighed the same as non-migrating individuals caught at the same time. Extra fattening is probably unnecessary because sparrowhawks in some regions migrate with their prey species, and thus can obtain food along the way (Rudebeck 1950, Cochran 1972, Newton 1986). The spring migrants in our study weighed considerably less than birds at other times of year. The mean body masses of adult Eurasian Sparrowhawks in our study were 33 g (females) and 14 g (males), lower than the mean for European birds (Cramp and Simmons 1980) and 20 g lower for both males and females than birds from the former Soviet Union (Dementiev 1966). The mass difference between migrants and non-migrants is not the result of size differences between populations.

TABLE 3. Body mass (g), wing chord (mm), and condition index (body mass/wing chord \times culmen length) of adult and yearling male and female Eurasian Sparrowhawks caught in Elat 1984–1988.

Group	Body mass (g)					Wing chord (mm)					Condition index				
	Mean	SD	n	W	P	Mean	SD	n	W	P	Mean	SD	n	W	P
Adult male	130	10	15			204	6	15			0.055	0.006	15		
Yearling male	139	39	10	174.5	<0.05	196	6	10	219	0.011	0.062	0.016	10	177	>0.05
Adult female	231	22	20			237	6	21			0.070	0.007	20		
Yearling female	214	20	27	589.5	0.019	232	4	25	612	0.009	0.065	0.006	24	541	0.033

Mean wing length of adult Eurasian Sparrowhawks in our study was the same as reported by Cramp and Simmons (1980) and Dementiev (1966). The lower body mass of birds during migration likely reflects reserves used for migration over deserts where chances for feeding are probably minimal. A similar comparison of body mass of Levant Sparrowhawks during migration and at other times of year was not possible because body mass data are not available for non-migration periods. Levant Sparrowhawk's wing chord data from our study are similar to data of Cramp and Simmons (1980) and Dementiev (1966), also to data from a 1996 study conducted in Elat (Clark and Yosef 1997).

Our finding that Eurasian Sparrowhawks migrating during spring weigh less than birds at other times of year is not unique to this species. The mean mass of spring migrating Steppe Buzzards in Elat was significantly lower than for the same species on their wintering grounds in southern Africa (Gorney and Yom-Tov 1994). Adult Eleonora's Falcons (*Falco eleonora*) during migration weighed 100 g less than adults on their breeding grounds (Cramp and Simmons 1980). Although data were not available for Levant Sparrowhawks, it is likely that they also lose weight during migration. In general birds are more likely to demonstrate considerable mass declines during spring migration in Elat because they must cover large stretches of desert on their way from Africa. Upon entering the Mediterranean area north of Elat these species probably begin replenishing their reserves (Yom-Tov and Ben-Shahar 1995). Indeed, Levant Sparrowhawks in autumn were not attracted to the same food in bal-chatri traps that attracted them during spring migration (E.G., pers. obs.).

Adults migrate in spring before young birds in most raptor species probably because of benefits they receive from early arrival to the breeding territories (Newton 1979, Kerlinger 1989). Their earlier passage is undoubtedly aided by better physical condition. In support of this, several researchers found larger fat reserves in adults than in immature birds (Dunn et al. 1988, Serie and Sharp 1989, Alerstam and Lindstrom 1990, Morton et al. 1990, Gorney and Yom-Tov 1994; but see Alerstam and Lindstrom 1990). Our data from this study of

two *Accipiter* species also demonstrate earlier trapping dates of adult than yearling birds. However, we found no difference in physical condition of Levant Sparrowhawks between adults and yearlings. In addition, Eurasian Sparrowhawk adult females were in significantly better condition than yearling females; however, we found no such trend among males.

ACKNOWLEDGMENTS

We thank K. Titus, B. Millsap and one anonymous reviewer for their comments on a previous draft of this paper. We thank Y. Leshem for his help and encouragement, B. Millsap for useful comments on the manuscript, and N. Paz for editorial comments. We are also indebted to many tireless field workers of whom we can mention but a few: M. Britain, K. Duffy, O. Hatzofe, Z. Labinger, J. Mason, M. McGrady, C. McIntyre, R. Parslow, T. Shochat, and C. Schultz. Thanks to Kibbutz Elot for their generous hospitality. This study was funded by the Israel Raptor Information Center of the Society for the Protection of Nature in Israel, the Inter-University Ecological Fund of the Jewish National Fund, and the Elat Ornithological Center.

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